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THE SRRL COBALT-60 FACILITY

by

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ABSTRACT

The SRRL cobalt-60 facility, including design, installation, operation, and safety, was described. A bibliography of published research reports of the useful applications of nuclear energy made by SRRL to agricultural utilization research, particularly cotton research, was included.

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The peaceful uses of nuclear energy, particularly fabricated radio-active sources and service irradiations made available by the United States Atomic Energy Commission, opened new areas for investigating utilization of farm commodities and derived chemical products. Studies on the use of nuclear energy in practical systems to effect changes in chemical structure, to catalyze chemical reactions, and to sterilize and preserve food products were indicated.

In planning the radiation facility for the wide range of research investigations indicated, it was obvious that considerable flexibility of operation was required. Dosages required might range from a few hundred roentgens to a hundred million roentgens. In order to keep the duration of experiments within reasonable periods of time, particularly chemical reactions, an initial dose rate of about one million roentgens per hour would be desirable. A minimum experimental volume of 150 ml. at this dose rate would make possible the irradiation of sizeable research samples. For other investigations, involving biological work and food products, much lower total dosages would be required; however, it would generally be desirable, in these cases to irradiate larger sized samples than in the case of chemical reactions. With these general requirements being considered, the SRRL radiation facility was planned.

SELECTION OF SOURCE

The selection of a nuclear radiation source was limited by availability to either cobalt-60 or cesium-137. The relative advantages of each type of radiation source were considered, as follows: (1) cesium-137 has a longer half-life which would be an advantage in maintaining initial activity; however, cobalt-60 with a 5.3-year half-life could be maintained at a high level with only infrequent substitution or supplementation; (2) a short-lived daughter product of cesium-137 emits a gamma ray having an energy of 0.66 Mev.; therefore, for comparable dose rates, less shielding would be required for cesium-137 than for cobalt-60 which emits a gamma ray having higher energy; (3) the dose rate per curie for cobalt-60 is about 3.5 times that for cesium-137. In view of these considerations and of the specific activity of sources available, it was decided that a cobalt-60 source, having an activity of at least 1000 curies, would more nearly meet out general requirements for ranges of dosages and sizes of research samples than a cesium-137 source.

SOURCE CAPSULE[3]

The design of a capsule to give a distributed source had the obvious advantage in that a more uniform radiation field over a larger volume could be obtained. A hollow brass cylinder (about 7 in. long, 2-3/8 in. outside diameter, and 1-3/8 in. inside diameter) closed at one end was made. Twelve peripheral holes (about 1 cm. in diameter) were drilled into the walls of the cylinder parallel to its axis at equally spaced intervals. In the place of one hole, a slot was cut the length of the cylinder. The center of the closed end of the cylin-

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[3] Compare with Ghormley, J. A., and Hochanadel, C. J., Rev. Sci. Instr. 22, 473 (1951).

der was drilled and threaded, so that the cylinder could be attached to a rod. This cylinder could be placed over and around containers, including those with side-arms.

The cobalt-60 (1000 curies) source was made up of 57 metallic discs of cobalt about 1 cm. in diameter and 1 mm. thick, weighing about 40 g. The discs were placed in the peripheral holes of the brass cylinder at calculated positions, using tubular spacers. The loading plan of the discs in the 11 holes was calculated to give a uniform field along the center axis of the cylinder. The capsule was loaded at the Oak Ridge National Laboratory.

SHIELD DESIGN[3]

The swimming pool, cave, and well types of shields were considered and rejected principally because the distances between the experimental setup and the experimenter during irradiation would be several feet. This would limit to some extent the flexibility of operation of the source.

The use of lead for shielding would safely place the experimenter within a few inches of the source. Then by the use of access ports, this type of shielding would allow him flexibility in planning experiments, involving stirring, heating, cooling, addition or removal of gases or liquids from contact with the samples, and even "periscope" viewing of the experiments during irradiation.

The shield was constructed in two sections: the bottom section was a large block of lead (33 in. wide, 54 in. long, 24 in. deep) covered with steel plate, containing two cubical cavities (8 x 8 x 8 in.) in which samples could be placed. The top section was a lead cylinder (26-½ in. diameter and 30 in. long) also covered with steel plate. The top section was mounted on a dolly and could be rolled manually on tracks over either cavity. The radiation shield in its final assembly is shown in Figure 1. A vertical section of the assembly is shown in Figure 2.

The hollow brass cylinder, which contained the cobalt-60, was held on the end of a vertically aligned rod inside the top section of the shield. The rod was of sufficient length to permit the cobalt-60 to be lowered from the top section of the shield to the full depth of either cavity of the bottom section of the shield. This rod emerged from the top section of the shield through an axial hole and was attached outside the shield to a parallel guide rod for vertical positioning of the source.

INSTALLATION

The top section of the shield also served as the shipping container. After loading of the source capsule with cobalt-60, it was placed in this section of the shield. Lead and steel plugs were inserted into the section. The lead plug was held in place by a removable pin and a steel plate. These are shown in Figure 1.

The installation of the top section containing the cobalt-60 is shown in Figure 3. After the section was positioned on the dolly, the steel plate was removed; then the section was lowered into its final position. The steel plug in the upper part of the section was removed, and the positioning rod was inserted and attached to the source capsule. Then the pin, holding the lead plug in position in the lower part of the section, was removed. This allowed the plug to fall into one of the cavities of the bottom section of the shield. (Note: Provisions have been made for the reinsertion of the lead plug into the top section of the shield without lifting the shield. This was accomplished by leaving an opening in the bottom of a cavity, normally closed with lead brick. It is possible to jack the lead plug into the top section of the shield through this opening without exposing personnel to radiation.)

[3] Compare with Ghormley, J. A., and Hochanadel, C. J., Rev. Sci. Instr. 22, 473 (1951)

OPERATION

After the source was installed on June 11, 1957, the uniformity of the dose rate along the center axis of the source capsule was determined. Ferrous-ferric dosimetry in 0.5 N sulfuric acid indicated a dose rate of about 700,000 roentgens per hour inside the cylinder. The dose rate was found to vary only about 5 percent from the ends to the middle of the capsule.

The minimum dose rate in the cubical cavities, without any attempt to reduce the dose rate by shielding but by leaving the source in the top section of the shield, was 2000 roentgens per hour. Periodically the calibration of the source is checked.

The relative positioning of the sample and the source determine the effective dose rate between the indicated limits. For the maximum dose rate, the samples were positioned in the center of the cavity in a vertical alignment. The source was lowered from the top section of the shield to over and around the sample. The maximum size of sample in this case was 150 ml. For minimum dose rate, the source remained in the top section of the shield, and the sample was positioned in the cavity horizontally with respect to the source. It was also possible to irradiate a number of samples simultaneously at the same dose rate or at different dose rates.

SAFETY

Shielding of about 12 in. of lead (24 half-value layers) is provided in all directions, except for the axial, vertical hole in the top section of the shield. In this case, however, the cobalt-60 is recessed under the 12 in. lead shield and the steel positioning rod provides some shielding. The radiation leakage is less than one milliroentgen per hour at one meter. During shipping, the maximum radiation leakage was 3.8 milliroentgens per hour at one meter around the lead plug. Extra shielding was provided in order that the total activity of the source could be increased at a later date without modifying the facility.

In the operation of the source, it is possible that the source capsule could become separated from the positioning rod or that the capsule could be left in an "on-position" when the top section of the shield is moved. In the first instance, the capsule is periodically tightened to the rod. If it should become separated and the top section of the shield was not moved, personnel would not be exposed to radiation. If the unlikely separation occurred, it is possible to "fish" through the hole in the top section of the shield into a cavity and again join the rod and the capsule. This was demonstrated prior to loading of the capsule with cobalt-60.

In the second instance, the external parallel guide rod (refer to Figure 1) recesses through a hole in a steel plate attached to the bottom section of the shield when the source is in an "on-position." It is not possible to move the top section of the shield, until this guide rod is raised to clear the plate. Since the guide rod is mechanically attached to the positioning rod holding the capsule, the capsule is raised when the guide rod is raised.

Of course, whenever the source capsule is moved, the facility is continuously monitored.

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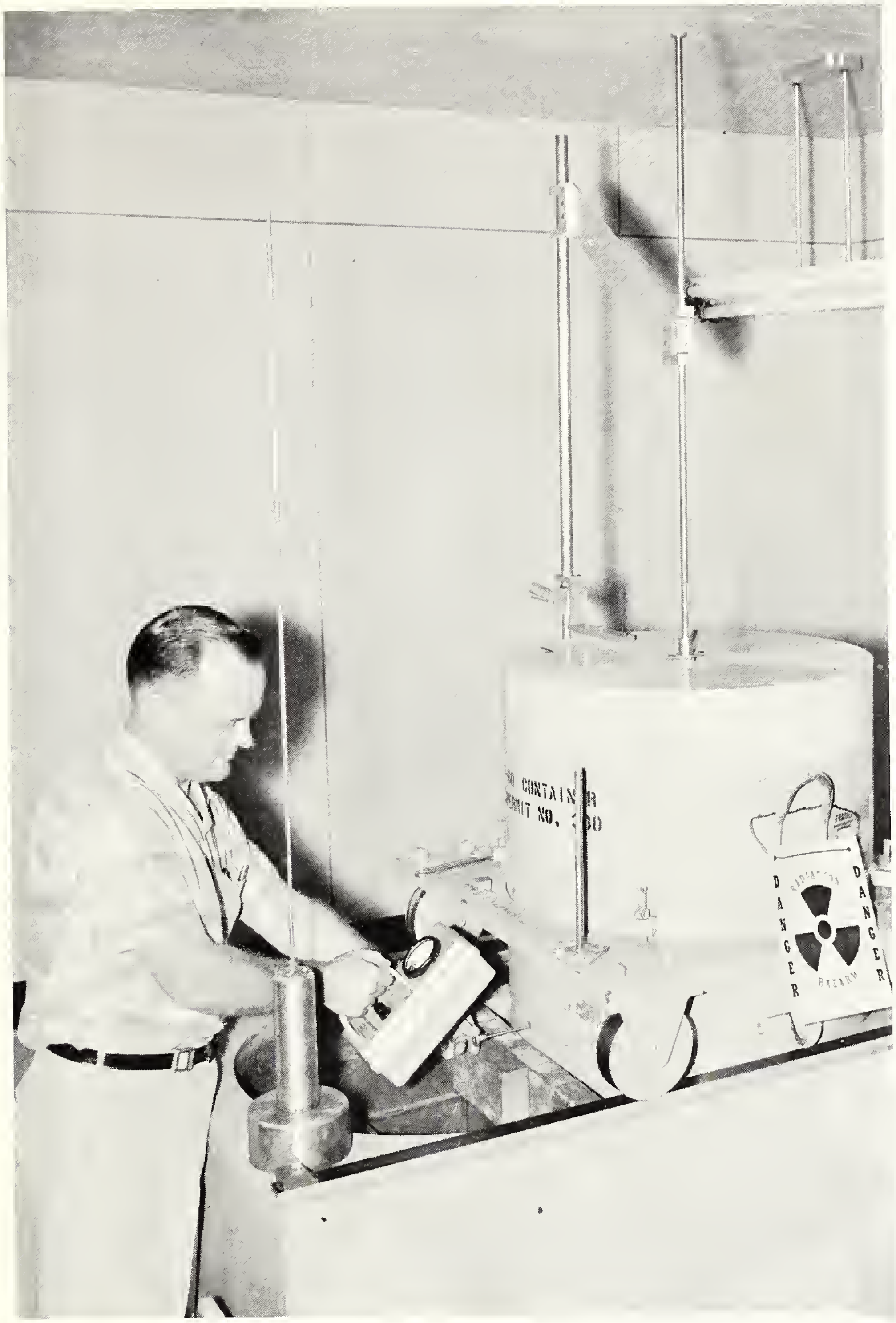

Figure 1.—*Final assembly of the SRRL Cobalt-60 facility.*

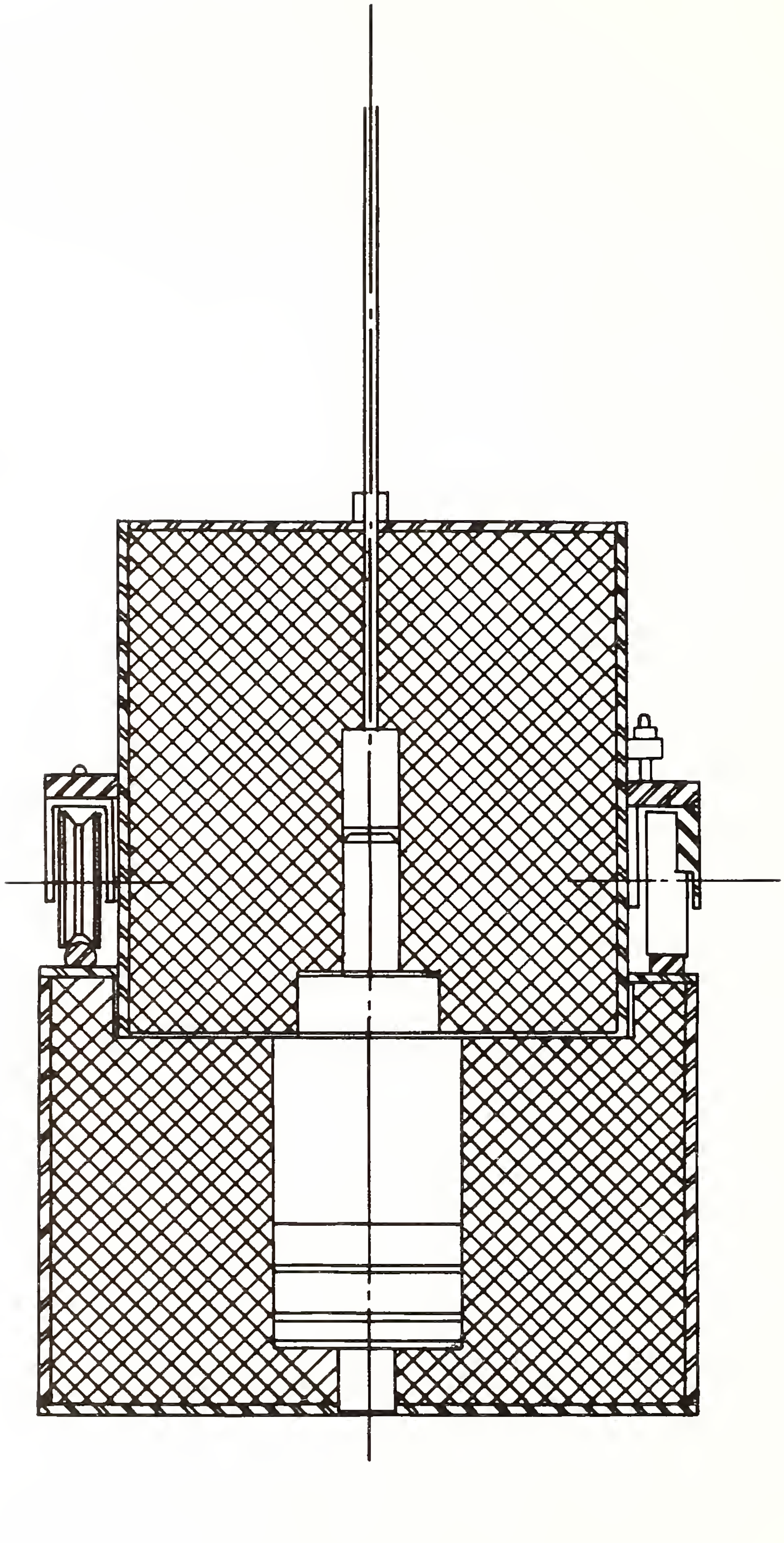

Figure 2.—*A vertical section of the final assembly.*

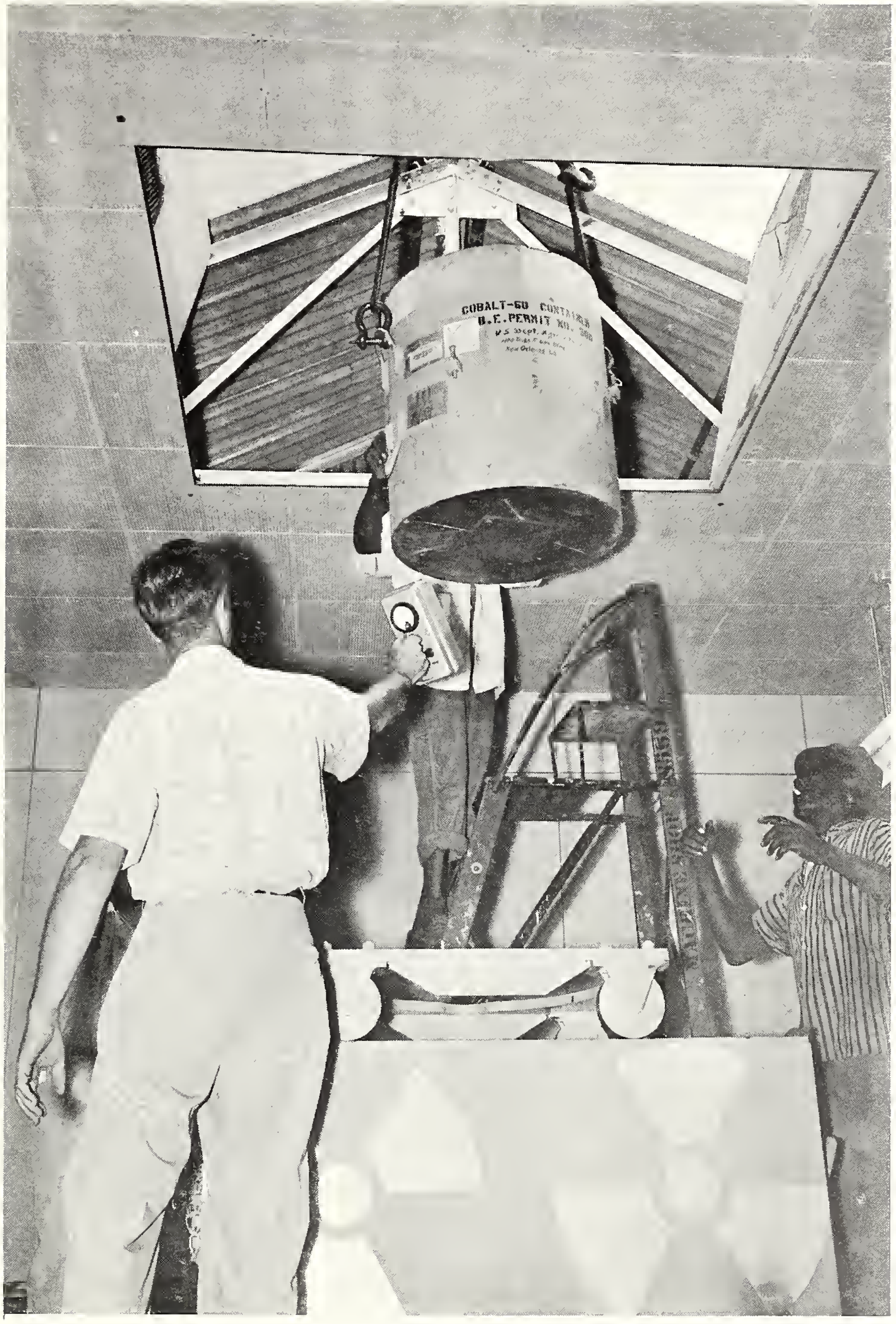

Figure 3.—*Installation of top section of the SRRL Cobalt-60 facility.*